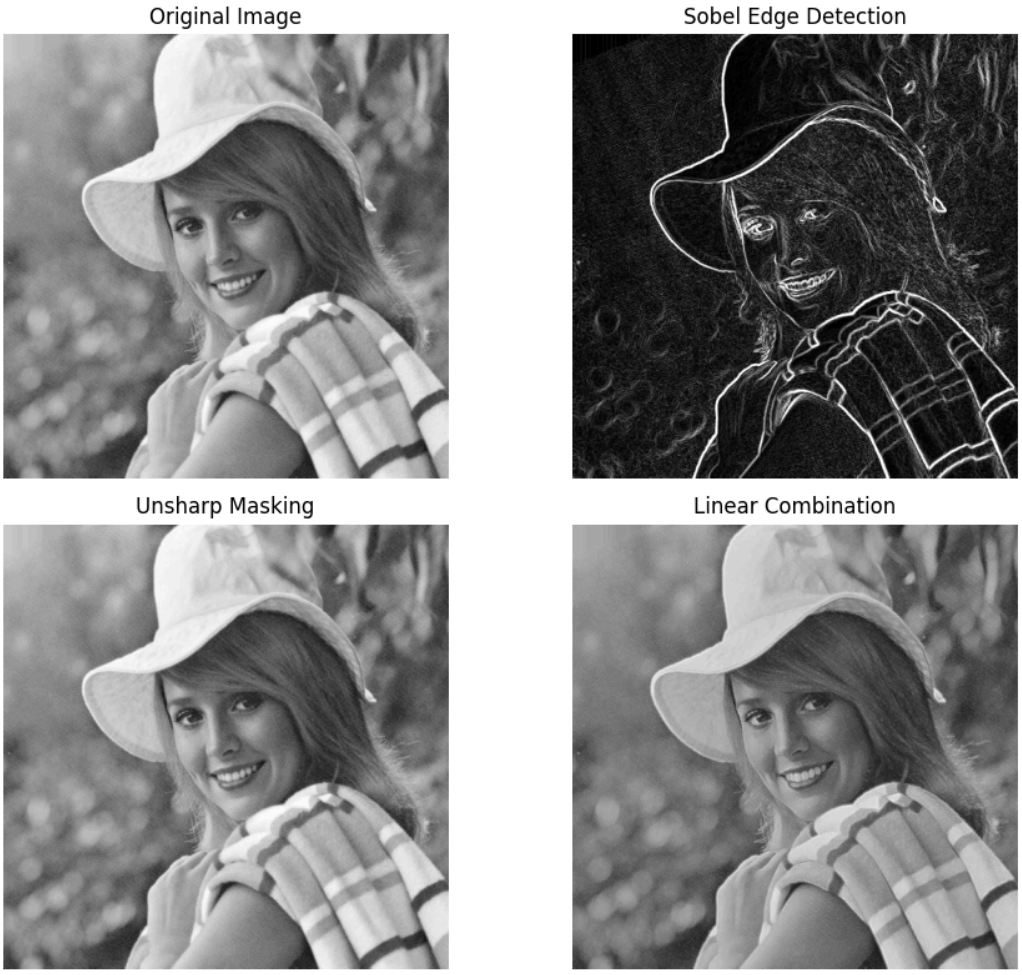
Project Report: Sobel Edge Detection + Unsharp Masking

This report details the implementation and results of image processing techniques focusing on Sobel edge detection and unsharp masking. To detect edges in an image, the Sobel edge detector was implemented and with the kernel in the lecture. The Sobel operator calculates the gradient of image intensity in both the horizontal and vertical directions using two convolution kernels. The horizontal kernel detects changes along the x-axis, while the vertical kernel captures variations along the y-axis. The combined gradient magnitude is computed as the square root of the sum of the squares of these gradients. To handle boundary effects, reflective padding was applied, ensuring no edge information was lost during processing.

Unsharp masking was implemented to enhance image sharpness using a 3x3 smoothing kernel. This technique involves first smoothing the image with the kernel specified in the lecture. These details are scaled by a user-defined factor k and added back to the original image to produce the sharpened result. The sharpening formula ensures that the processed image retains its structure while emphasizing edges and fine details.

To evaluate the methods, a test image was processed using the Sobel edge detector and the unsharp masking function. Additionally, a linear combination of the original image and its Sobel edge-detected version was computed to blend edge enhancements with the original image. The formula used for the combination was: (0.85 * img) + (0.15 * sobel). This produced a balanced output that integrated both original and edge-highlighted features.



The results of these transformations were analyzed using two metrics: Root Mean Square Error (RMSE) and Mean Square Error (MSE). These metrics quantify the differences between the original and processed images. For the Sobel edge detection, the RMSE was 10.2708, and the MSE was 105.4900, reflecting significant changes due to the edge enhancement. The unsharp masking transformation showed minimal alteration with an RMSE of 0.7094 and an MSE of 0.5033, aligning with its goal of subtle enhancement. The linear combination yielded an RMSE of 9.9097 and an MSE of 98.2021, indicating moderate changes as expected from blending.

```
(venv) natashapiedrabuena@Natashas-MacBook-Pro-3 Image_Processing % python3 project_5/main.py
Available TIFF files from Testing directory:
1: Girl.tif
2: Airplane-F16.tif
3: Bridge.tif
4: Barbara.tif
5: Lena_Y.tif
6: Lake_Y.tif
7: SailBoat.tif
8: Boat.tif
9: Lena_Y-Scratches.tif
10: BigBen.tif
11: Lena_Color.tif
12: LowContrast-a.tif
13: Temple_Y.tif
14: LowContrast-b.tif
15: Pepper_Y.tif
16: Airplane-F16_Y.tif
17: LowContrast-c.tif
18: Pepper.tif
Choose the first file (1-18): 1
Processing files: ./Test_Images/Girl.tif
Enter k: 0.15
Enter alpha: 0.85
```

Transformation	RMSE	MSE
Edge Detection	10.2708	105.49
Unsharp Masking	0.7094	0.5033
Linear Combination	9.9097	98.2021

In conclusion, the Sobel edge detector effectively highlighted edges, while unsharp masking enhanced image sharpness with minimal distortion at the k that it was specified to be 0.15.